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DIODE STEP STRESS TESTING PROGRAM

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FINAL REPORT
FOR
JANTX 1N937B

FEBRUARY 1979

Prepared
For

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FOREWORD

This is a summary of the work performed on NASA Contract NAS8-31944. The investigation was conducted for the National Aeronautics and Space Administration, George C. Marshall Space Flight Center, Huntsville, Alabama. The Contracting Officer's Technical Representative was Mr. F. Villella.

The short-term objective of this preliminary study of transistors, diodes, and FETS is to evaluate the reliability of these discrete devices, from different manufacturers, when subjected to power and temperature step stress tests.

The long-term objective is to gain more knowledge of accelerated stress testing for use in future testing of varieties of discrete devices, as well as to determine which type of stress should be applied to a particular type of device or design.



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1.0

INTRODUCTION

DCA Reliability Laboratory, under Contract NAS8-31944 for NASA/Marshall Space Flight Center, has compiled data for the purpose of evaluating the effect of power/temperature step stress when applied to a variety of semiconductor devices. This report covers the zener diode JANTX1N937B manufactured by Motorola and Siemens.

A total of 48 samples from each manufacturer were submitted to the process outlined in Table 1. In addition, two control sample units were maintained for verification of the electrical parametric testing.

2.0

TEST REQUIREMENTS

2.1

Electrical

All test samples were subjected to the electrical tests outlined in Table 2 after completing the prior power/temperature step stress point. These tests were performed using the Fairchild Model 600 high-speed computer-controlled tester. Additional bench testing was also required on the devices.

2.2

Stress Circuit

The test circuit shown in Figure 1 was used to power all of the test devices during the power/temperature stress conditions. The voltage was set by V_z and the current was varied in order to comply with the specified power rating for this device. At least one of the devices was subjected to maximum rated power (MRP). All remaining devices were subjected to no less than 90% of MRP. See Figure 1 for load resistance values and voltages.



2.3

Group I - Power Stress

Thirty-two units, 16 from each manufacturer, were submitted to the power stress process. The diodes were stressed in 500-hour steps at 50, 100, 125, 150, and 175 percent of maximum rated power for 2500 hours or until 50% or more of the devices in a sample lot failed.* Electrical measurements were performed on all specified electrical parameters after each power step. See Table 1.

2.4

Group II - Temperature Stress I

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress I Process. Group II was subjected to 1600 hours of stress at maximum rated power in increments of 160 hours. The temperature was increased in steps of 25°C, commencing at 75°C and terminating at 300°C or until 50% or more of the devices failed.* Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table 1.

2.5

Group III - Temperature Stress II

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress II process. Group III was subjected to 112 hours of stress at maximum rated power in increments of 16 hours. The temperature was increased in steps of 25°C, commencing at 150°C and terminating at 300°C or until 50% or more of the devices in the sample lot failed.* Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table 1.

* Conditions for failure:

- A) Open or short
- B) Leakage exceeds the maximum limit by 100 times
- C) Other parameters exceed MIL limits by 50% or more.



3.0 DISCUSSION OF TEST RESULTS

3.1 Group I - Power Stress

3.1.1 Motorola. The Motorola sample lot completed 2150 hours of Group I Testing before the lot was stopped because 50% of the devices failed. The first two failures occurred 150 hours into the 150% MRP step. Serial numbers 5236 and 5242 failed the minimum B_V limit. The next failure occurred 10 hours into the 175% MRP step. Serial number 5229 failed the minimum B_V limit. The next failure occurred 50 hours into the 175% MRP step. Serial number 5227 failed the minimum B_V limit. The last four failures occurred 150 hours into the 175% MRP step. Serial numbers 5230, 5235, 5237, and 5239 failed the minimum B_V limit. Typical characteristics of this sample lot's performance were:

- 1) The mean value for B_V changed 4.326V from an initial mean of 8.958V to a final mean of 4.632V.

The control units for this sample lot remained constant throughout the entire Group I Testing.

3.1.2 Siemens. The Siemens sample lot completed 2010 hours of Group I Testing before the lot was stopped because more than 50% of the devices failed. The first failure occurred 250 hours into the 100% MRP step. Serial number 5180 failed the minimum B_V limit. Serial number 5173 was recorded as a missing part 500 hours into the 100% MRP step. The next failure occurred 50 hours into the 125% MRP step. Serial number 5185 failed the minimum B_V limit. The next failure occurred 10 hours into the 150% MRP step. Serial number 5183 failed the



minimum B_V limit. The next failure occurred 25 hours into the 150% MRP step. Serial number 5188 failed the minimum B_V limit. The next failure occurred 150 hours into the 150% MRP step. Serial number 5176 failed the minimum B_V limit. The last four failures occurred 10 hours into the 175% MRP step. Serial numbers 5174, 5177, and 5181 failed the minimum B_V limit. Serial number 5182 failed the maximum B_V limit. Typical characteristics of this sample lot's performance were:

- 1) The mean value for B_V changed 4.609V from an initial mean of 9.159V to a final mean of 4.550V.

The control units for this sample lot remained constant throughout the entire Group I Testing.

3.1.3 Statistical Summary - Group I

Table 4 outlines the results of Group I - Power Stress Testing for the electrical parameter and all of the measurement points for both Motorola and Siemens.

3.2 Group II - Temperature Stress I

- #### 3.2.1 Motorola.
- The Motorola sample lot completed the entire 1600-hour Group II Testing with six catastrophic failures. The first failure occurred 160 hours into the 200°C-temperature step. Serial number 5255 failed the minimum B_V limit. The next three failures occurred 160 hours into the 275°C-temperature step. Serial numbers 5249, 5253, and 5258 failed the minimum B_V limit. The last two failures occurred 160 hours into the 300°C-temperature step. Serial numbers 5247 and 5259 failed the minimum B_V limit. Typical characteristics of this sample lot's performance were:



- 1) The mean value for B_V changed 3.198V from an initial mean of 8.933V to a final mean of 5.735V.

The control units for this sample lot remained constant throughout the entire Group II Testing.

3.2.2 Siemens. The Siemens sample lot completed the entire 1600-hour Group II Testing with nine catastrophic failures. The first failure occurred 160 hours into the 175°C-temperature step. Serial number 5190 failed the minimum B_V limit. The next two failures occurred 160 hours into the 250°C-temperature step. Serial numbers 5203 and 5204 failed the minimum B_V limit. The next three failures occurred 160 hours into the 275°C-temperature step. Serial numbers 5195, 5197, and 5202 failed the minimum B_V limit. The last three failures occurred 160 hours into the 300°C-temperature step. Serial numbers 5189, 5193, and 5199 failed the minimum B_V limit. Typical characteristics of this sample lot's performance were:

- 1) The mean value for B_V changed 4.225V from an initial mean of 9.121V to a final mean of 4.896V.

The control units for this sample lot remained constant throughout the entire Group II Testing.

3.2.3 Statistical Summary - Group II. Table 5 outlines the results of Group II - Temperature Stress I Testing for the electrical parameter and all of the measurement points for both Motorola and Siemens.

3.3 Group III - Temperature Stress II

3.3.1 Motorola. The Motorola sample lot completed the entire 112-hour Group III testing with one catastrophic failure. Serial numbers 5271 and 5269 were removed



from the Group III Testing as MIL-STD-19500 limit failures 16 hours into the 200°C- and 225°C-temperature steps, respectively. The catastrophic failure occurred 16 hours into the 250°C-temperature step. Serial number 5261 failed the minimum B_V limit. Typical characteristics of this sample lot's performance were:

- 1) The mean value for B_V changed .552V from an initial mean of 8.925V to a final mean of 8.373V.

The control units for this sample lot remained constant throughout the entire Group III Testing.

3.3.2 Siemens. The Siemens sample lot completed the entire 112-hour Group III Testing with six catastrophic failures. The first four failures occurred 16 hours into the 200°C-temperature step. Serial numbers 5206, 5214, 5218, and 5219 failed the minimum B_V limit. The last two failures occurred 16 hours into the 300°C-temperature step. Serial numbers 5210 and 5212 failed the minimum B_V limit. Typical characteristics of this sample lot's performance were:

- 1) The mean value for B_V changed 1.443V from an initial mean of 9.107V to a final mean of 7.664V.

The control units for this sample lot remained constant throughout the entire Group III Testing.

3.3.3 Statistical Summary - Group III. Table 6 outlines the results of Group III - Temperature Stress II Testing for the electrical parameter and all of the measurement points for both Motorola and Siemens.



4.0

FINAL DATA SUMMARY

Table 7 statistically summarizes the change in the mean value from the zero-hour data to the final data. The graphs of Figures 2 and 4 plot the cumulative percent failures versus the temperature stress level for Group II - Temperature Stress I, and Group III - Temperature Stress II. The graphs of Figures 3 and 5 plot the time step for Group II (160 hours) and Group III (16 hours) versus the temperatures T_1 and T_2 calculated from Figures 2 and 4. Tables 8 and 9 summarize the failures encountered for all three stress groups. The failures are separated into two categories: catastrophic failures in Table 8 and parametric failures in Table 9. The data from Table 8 was used as a source for the graphs in Figures 2 and 4. Figures 2 and 4 were used as a source for the graphs in Figures 3 and 5 respectively. Junction temperature is plotted on an inverse hyperbolic scale.

5.0

CONCLUSIONS

The apparent failure mode in all three stress groups was the B_V minimum failure. Although both manufacturers had approximately the same amount of failures in each testing, the Motorola failures came later in the testings than those in the Siemens sample lots.

The Siemens and Motorola diodes are constructed with two anode dice forward biased and one cathode die reverse biased. When failure analysis was performed one anode die was operational, and the reverse biased dice on many of the failures exhibited soft resistive



curves. This indicates damage to the junctions due to micro-plasmas induced by the thermal and electrical stress of the burn-in.

A plot showing cumulative failure distribution for Groups II and III was drawn for the Motorola sample lot (Figures 2 and 3), but a complete plot for the Siemens sample lot could not be drawn due to an absence of main failure points in the Group III Testing (Figures 4 and 5). Figures 2 and 3 display the data for the Motorola sample lot used to calculate an activation energy of 1.95eV.

A broken circle around a marked point on the graph indicates a freak failure not calculated as part of the regression line. A solid circle around a marked point indicates an isolated failure point. The regression line was calculated using the least squares method.

The activation energy was calculated from the formula:

$$E = \left[\ln \left(\frac{t_1}{t_2} \right) \right] \left[\frac{8.63 \times 10^{-5} \text{ eV/}^{\circ}\text{K}}{\left(\frac{1}{T_1 + 273} \right) - \left(\frac{1}{T_2 + 273} \right)} \right] \text{ eV}$$

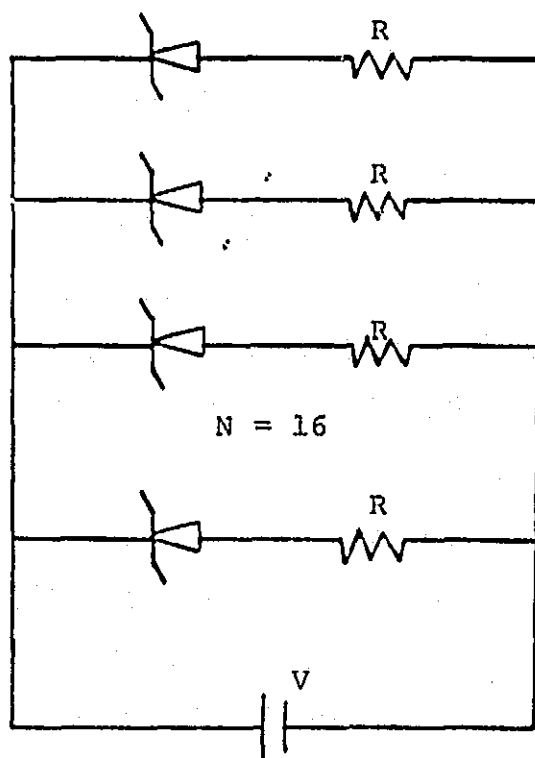
Where: t_1 = step of Group II - Temp Stress I = 160 hrs.
 t_2 = step of Group III - Temp Stress II = 16 hrs.
 T_1 = temperature in $^{\circ}\text{C}$ of 16% failure for Group II.
 T_2 = temperature in $^{\circ}\text{C}$ of 16% failure for Group III.



FIGURE 1

JANTX1N937B

ZENER DIODES



$$R = V_Z \div 1.75 I_{Z_{MAX}} \pm 50\%$$

$$P_d = V_Z^2 \div R$$

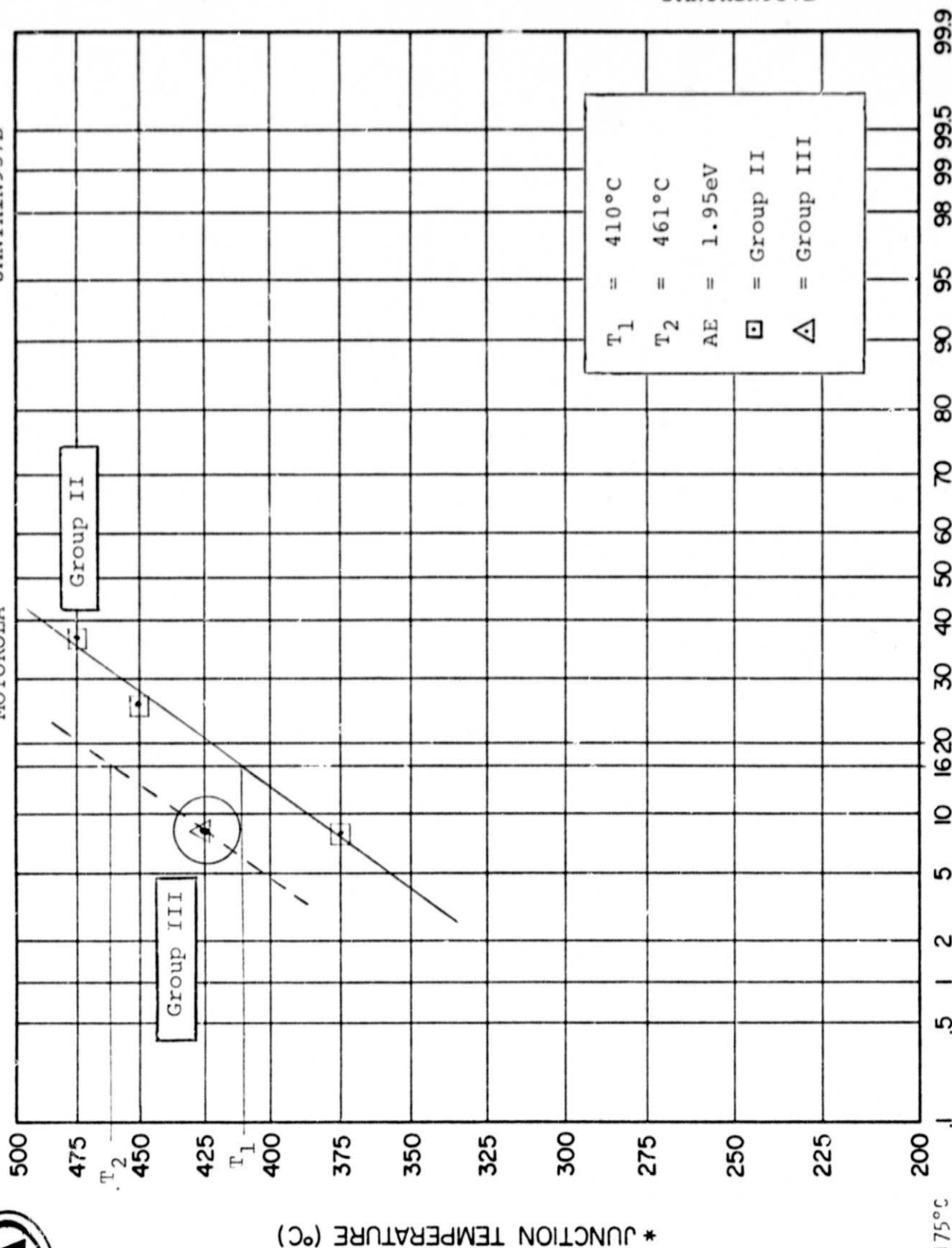
Power/Temperature Stress Circuit
for JANTX1N937B



MOTOROLA

JANTX1N937B

JANTX1N937B



*NOTE

$$T_J \approx T_A + 175^\circ\text{C}$$

FIGURE 2
Cumulative Percent Failures Versus Junction Temperature, Motorola

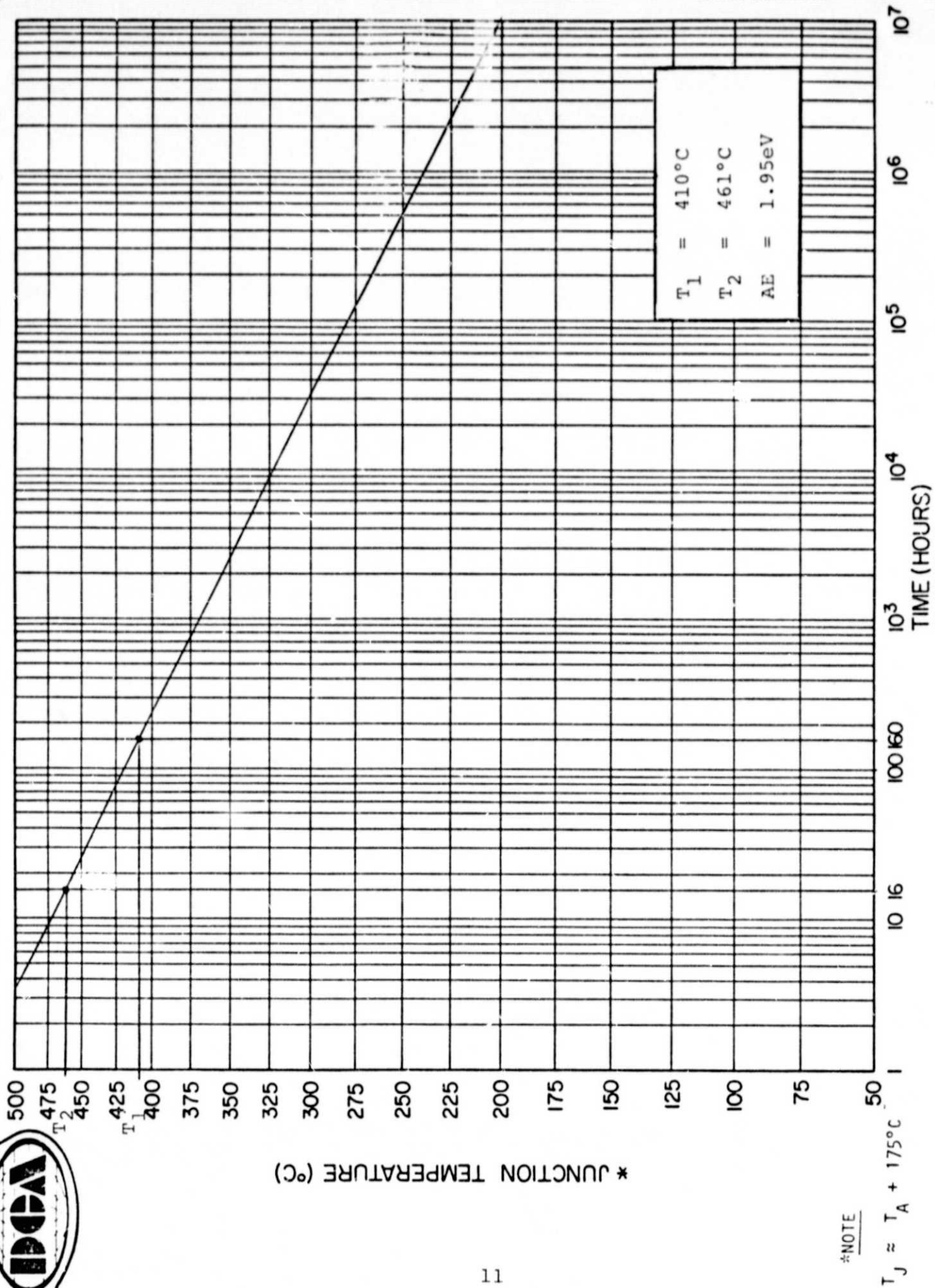


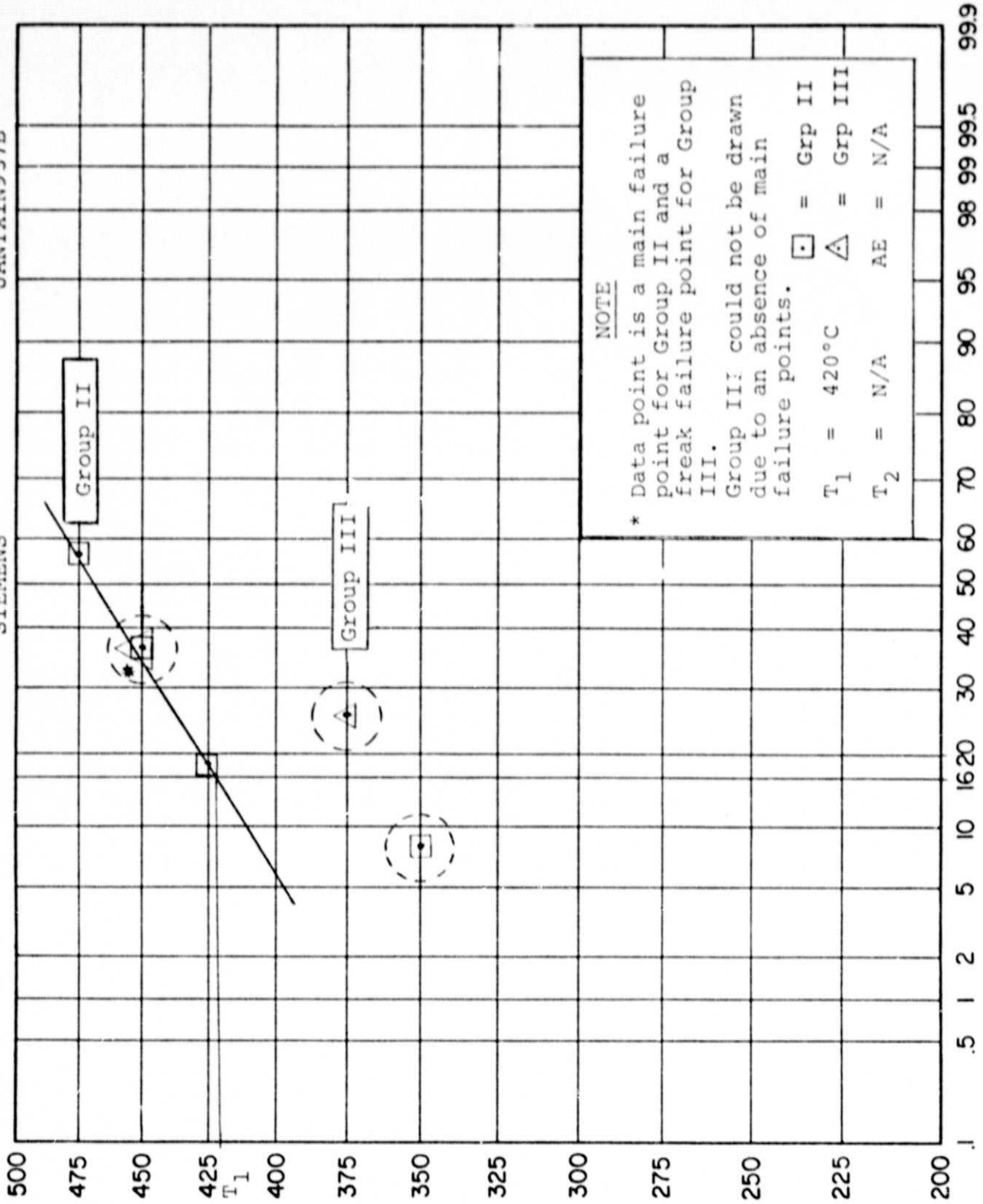
FIGURE 3
 Time Steps Versus Junction Temperature, Motorola



SIEMENS

JANTX1N937B

JANTX1N937B



NOTE

* Data point is a main failure point for Group II and a break failure point for Group III.

Group II: could not be drawn due to an absence of main failure points.

$T_1 = 420^\circ\text{C}$ $\square = \text{Grp II}$
 $T_2 = \text{N/A}$ $\triangle = \text{Grp III}$
 $AE = \text{N/A}$

FIGURE 4
Cumulative Percent Failures Versus Junction Temperature, Siemens

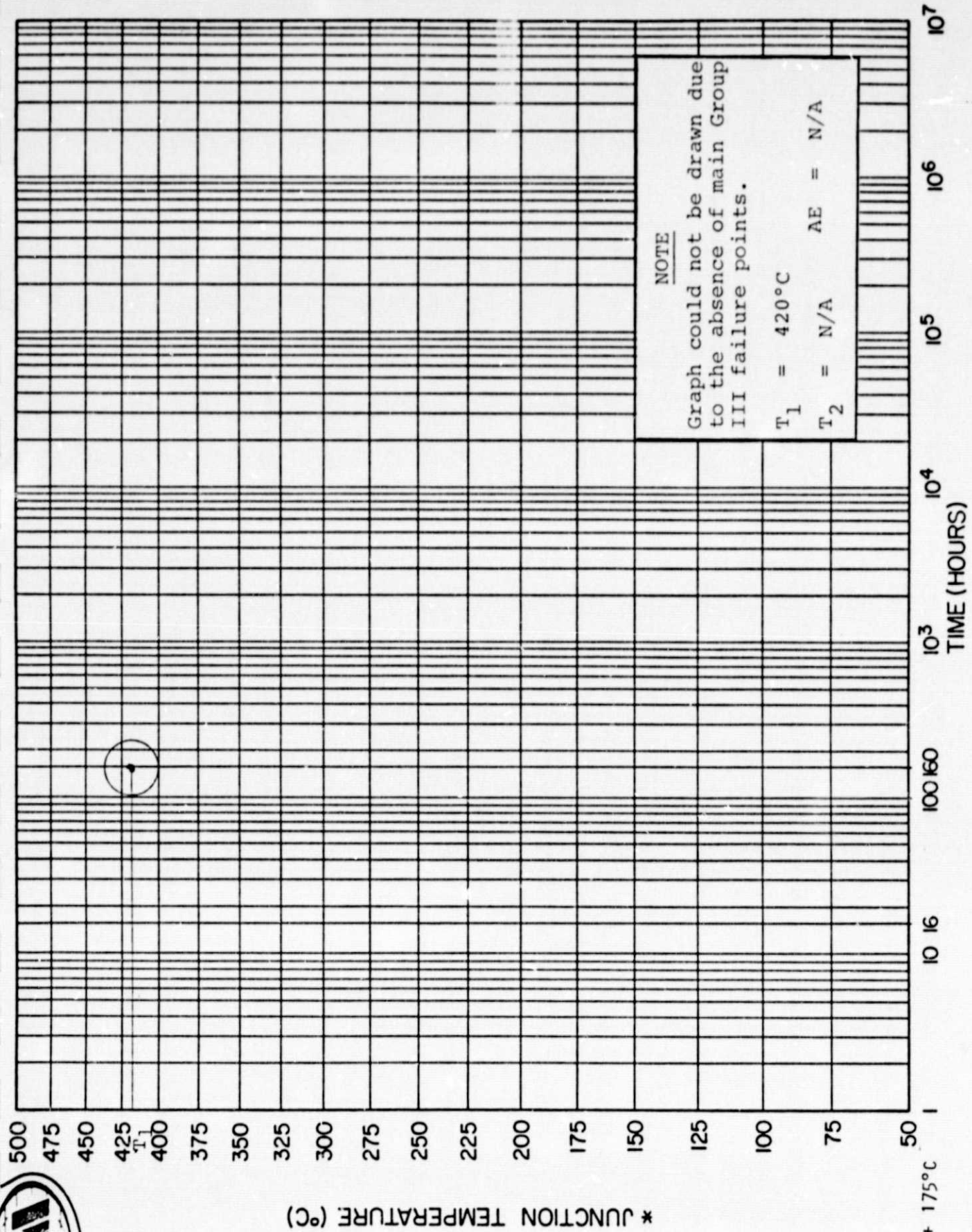


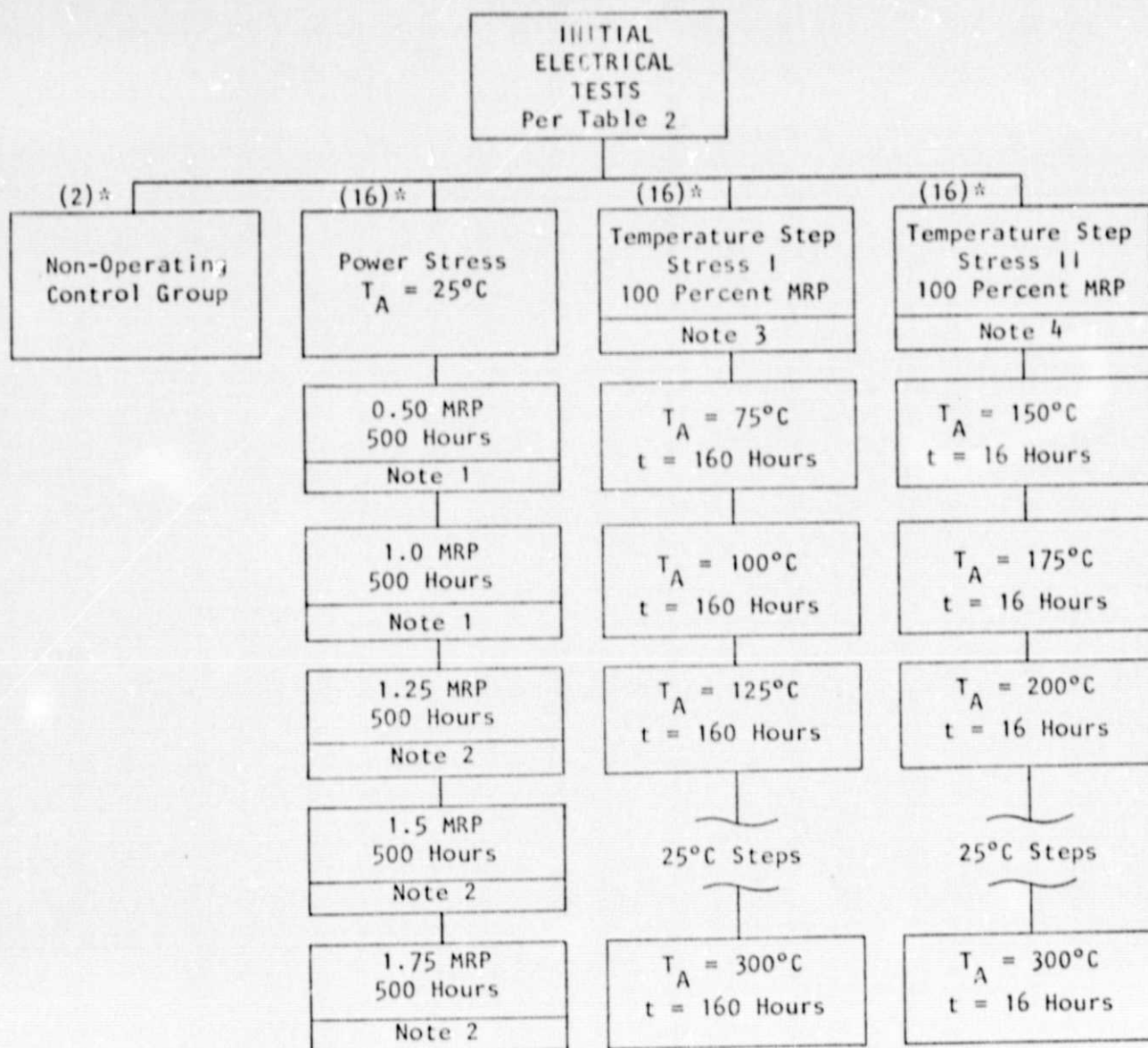
FIGURE 5
 Time Steps Versus Junction Temperature, Siemens

*NOTE

$$T_J \approx T_A + 175^\circ\text{C}$$

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TABLE 1
TEST FLOW DIAGRAM

*Quantity per manufacturer (Motorola and Siemens)

NOTES:

- 1) Electrical measurements per Table 2 were made at 50, 150, 250 and 500 hours.
- 2) Electrical measurements per Table 2 were made at 10, 25, 50, 150, 250 and 500 hours.
- 3) Electrical measurements per Table 2 were made at the end of each 160 hours.
- 4) Electrical measurements per Table 2 were made at the end of each 16 hours.



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TABLE 2
PARAMETERS AND TEST CONDITIONS

PARAMETER	CONDITIONS	SPEC LIMITS		CAT. LIMITS *		UNITS
		MIN	MAX	MIN	MAX	
B_V	@ $I_Z = 7.5 \pm .01 \text{mA}$	8.55	9.45	4.275	14.175	V
NOTES: * In addition, any open or short shall be considered catastrophic.						

TABLE 3
POWER STRESS BURN-IN CONDITIONS

$V_Z = 9.0 \text{V}$	
$I_Z =$	% P_D
27.5mA	50
55.0mA	100
68.75mA	125
82.5mA	150
96.25mA	175



NOTE
FOR TABLES
4 THROUGH 7

The minimum/maximum initial and final data generally have an absolute accuracy of $\pm 1\%$ of the reading and $\pm$ one digit except for readings greater than 9.99mA which have an absolute accuracy of $\pm 2\%$ of the reading and $\pm$ one digit. The data also has a resolution for four digits. The standard deviations, means, delta means, and average means are, therefore, valid indicators of trends over time and temperature, excepting the minor statistical computer error of supplying a constant number of significant digits.



NOTE
FOR TABLES
4 THROUGH 7

The minimum/maximum initial and final data generally have an absolute accuracy of $\pm 1\%$ of the reading and $\pm$ one digit except for readings greater than 9.99mA which have an absolute accuracy of $\pm 2\%$ of the reading and $\pm$ one digit. The data also has a resolution for four digits. The standard deviations, means, delta means, and average means are, therefore, valid indicators of trends over time and temperature, excepting the minor statistical computer error of supplying a constant number of significant digits.



JANTX1N937B

TABLE 4
GROUP I - POWER STRESS DATA SUMMARY

Page 1 of 2

PARAMETER	$B_V = 8.55V (MIN) \ 9.45V (MAX)$				
CONDITIONS AND LIMIT	@ $I_Z = 7.5^{+}.01mA$				
IDENTIFICATION	MOTOROLA	SIEMENS			
INITIAL DATA					
MIN VALUE	8.640V	8.953V			
MAX VALUE	9.084V	9.366V			
MEAN	8.958V	9.159V			
STD DEV	.1404V	.08528V			
INTERIM DATA					
POWER 50 TO 125% Δ MEAN VALUE					
50% POWER					
50 Hours	-.001V	-.001V			
150 Hours	-.000V	-.000V			
250 Hours	-.001V	-.001V			
500 Hours	-.001V	-.001V			
100% POWER					
550 Hours	+.007V	-.004V			
650 Hours	+.013V	*-.276V			
750 Hours	+.017V	-.010V			
1000 Hours	+.016V	-.009V			
125% POWER					
1010 Hours	+.018V	-.010V			
1025 Hours	+.191V	-.010V			
1050 Hours	+.018V	-.013V			
1150 Hours	+.019V	-.008V			
1250 Hours	+.018V	+.004V			
1500 Hours	+.018V	-.002V			

(continued on second sheet)

TABLE 4 (Cont'd)
— POWER STRESS DATA SUMMARY

Page 2 of 2

(continued from first sheet)

PARAMETER	B _V = 8.55V (MIN) 9.45V (MAX)				
CONDITIONS AND LIMITS	@ I _Z = 7.5 ⁺ .01mA				
IDENTIFICATION	MOTOROLA	SIEMENS			
INITIAL DATA					
MIN VALUE	8.640V	8.953V			
MAX VALUE	9.084V	9.366V			
MEAN	8.958V	9.159V			
STD DEV	.1404V	.08528V			
INTERIM DATA					
POWER 150 TO 175% Δ MEAN VALUE					
150% POWER					
1510 Hours	+ .014V	* -.694V			
1525 Hours	+ .016V	* -1.416V			
1550 Hours	- .020V	- .614V			
1650 Hours	* -.471V	* -1.075V			
1750 Hours	- .501V	- 2.201V			
2000 Hours	- 1.552V	- 2.405V			
175% POWER					
2010 Hours	* -1.909V	* -4.609V			
-----		-----			
2025 Hours	- 2.022V	Job Stopped			
2050 Hours	* -2.215V				
2150 Hours	* -4.326V				

2250 Hours	Job Stopped				
2500 Hours					
FINAL DATA					
MIN VALUE	.967V	1.388V			
MAX VALUE	8.681V	6.055V			
MEAN	4.632V	4.550V			
STD DEV	2.644V	1.393V			

NOTE: Catastrophic Rejects removed from data.

TABLE 5

GROUP II TEMP STRESS I DATA SUMMARY

PARAMETERS	B _V =8.55V (MIN) 9.45V (MAX)					
CONDITIONS AND LIMITS	@ I _Z =7.5 ⁺ .01mA					
IDENTIFICATION	MOTOROLA	SIEMENS				
INITIAL DATA						
MIN VALUE	8.664V	8.926V				
MAX VALUE	9.065V	9.221V				
MEAN	8.933V	9.121V				
STD DEV	.1466V	.07639V				
INTERIM DATA (INITIAL TO FINAL)						
Δ MEAN VALUE						
Total Hours	Temp (T _A)					
160	75°C					
320	100°C		+ .003V			- .005V
480	125°C		+ .016V			- .007V
640	150°C		+ .019V			- .025V
800	175°C		- .116V			- .025V
960	200°C		- .245V			* - .433V
1120	225°C		* - .444V			- .632V
1280	250°C		- 1.684V			- 1.872V
1440	275°C		- 2.525V			* - 2.713V
1600	300°C		* - 3.297V			* - 4.104V
			* - 3.198V			* - 4.225V
FINAL DATA						
FINAL TEMP	300°C	300°C				
MIN VALUE	1.365V	1.554V				
MAX VALUE	7.065V	7.719V				
MEAN	5.735V	4.896V				
STD DEV	1.488V	1.439V				

NOTE: CATASTROPHIC REJECTS REMOVED FROM DATA

TABLE 6

GROUP III TEMP STRESS II DATA SUMMARY (16 Hours)

PARAMETERS	$B_V = 8.55V (MIN) \ 9.45V (MAX)$								
CONDITIONS AND LIMITS	@ $I_Z = 7.5 \pm .01mA$								
IDENTIFICATION	MOTOROLA	SIEMENS							
INITIAL DATA									
MIN VALUE	8.654V	8.730V							
MAX VALUE	9.109V	9.268V							
MEAN	8.925V	9.107V							
STD DEV	.1765V	.1310V							
INTERIM DATA (INITIAL TO FINAL)									
Δ MEAN VALUE									
Total Hours	Temp (T_A)								
16	150°C	-.008V							
32	175°C	-.005V							
48	200°C	*-1.427V							
64	225°C	-.100V							
80	250°C	-.721V							
96	275°C	*-.969V							
112	300°C	-1.443V							
FINAL DATA									
FINAL TEMP	300°C	300°C							
MIN VALUE	4.455V	4.289V							
MAX VALUE	9.122V	9.127V							
MEAN	8.373V	7.664V							
STD DEV	1.199V	1.619V							

NOTE: CATASTROPHIC REJECTS REMOVED FROM DATA



JANTX1N937B

TABLE 7
FINAL DATA SUMMARY

PARAMETER	SPECIFICATIONS LIMIT		U N I T S	MEAN INT. DATA	AVERAGE Δ IN MEAN VALUE					
	MIN	MAX			POWER STRESS		TEMPERATURE STRESS I		TEMPERATURE STRESS II	
B _V	8.55	9.45	V		* -.52725	* -.63595	* -1.1471	* -1.4041	* -.20629	* -.66757

* NOTE: Catastrophic reject(s) removed from data.



APPENDIX A

FAILURE ANALYSIS

Power Stress



MSFC STEP-STRESS TEST
FAILURE ANALYSIS

DIODES
(Power Stress)

JANTX1N937B

Date 6 December 1978

N 2CN242-36A P/N 1N937B MFR Siemens

End Points:
4.28-14.18V

S/N	PIV -volts- @7.5±.01mA	I _r @ _____ V.dc	V _f @ _____ dc	INITIAL REJ. @ Seq. #:	INITIAL REJ. FOR:
583	3.0 (S)			31 (150 % MRP 1510 Hrs.)	B _v
5185	4.2 (S)			23 (125 % MRP 1050 Hrs.)	B _v
5188	2.05 (R)			33 (150 % MRP 1525 Hrs.)	B _v

INTERNAL DIE PROBE

S/N 5188 was opened on one side by grinding and internally probed. Starting from the anode end there were two forward and one reverse-biased diodes. The reverse diode junction is damaged. The breakdown voltages of the three dice in normal operation were: 0.3V (S), 0.5V (S), 1.3V (R). See Figure A-1.

INTERNAL VISUAL INSPECTION

No significant visual defects were seen.

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*h_{FE} trace present. Cannot meet stated test conditions. (Leaky)

*h_{FE} trace very leaky.

D = drift H = hysteresis Inv = inversion R = resistive S = soft Uns = unstable



MSFC STEP-STRESS TEST
FAILURE ANALYSIS
DIODES
(Power Stress)

JANTX1N937B

Date 6 December 1978

N 2CN242-36A P/N 1N937B MFR Motorola

End Points:
4.28-14.18V

S/N	PIV -volts- @7.5+.01mA	I _r @ _____ V.dc	V _f @ _____ dc	INITIAL REJ. @ Seq. #:	INITIAL REJ. FOR:
5 29	2.05 (S)			43 (175% MRP 2010 Hrs.)	B _v
5 30	1.50 (R)			49 (175% MRP 2150 Hrs.)	B _v
5236	2.7 (R)			37 (150% MRP 1650 Hrs.)	B _v

INTERNAL DIE PROBE

S/N 5236 was opened on one side by grinding and internally probed. Starting from the anode end there were two forward and one reverse biased diodes. The reverse diode junction is damage. The breakdown voltages of the three dice in normal operation were: 0.7V, 0.7V, 1.3V.

INTERNAL VISUAL INSPECTION

No significant visual defects were seen (see Figure A-2).

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*hFE trace present. Cannot meet stated test conditions. (Leaky)

*hFE trace very leaky.

D = drift H = hysteresis Inv = inversion R = resistive S = soft Uns = unstable



JANTX1N937B

CONCLUSIONS

These Siemens and Motorola diodes are constructed with the two anode dice forward biased and the cathode die reverse biased. When the case was partially ground away so that the internal structures could be probed, all anode (forward biased) dice were operational. The reverse-biased dice of all these samples exhibited soft resistive curves. This indicates damage to the junctions due to micro-plasmas induced by the thermal and electrical stress of the burn-in. (See probe data above.)

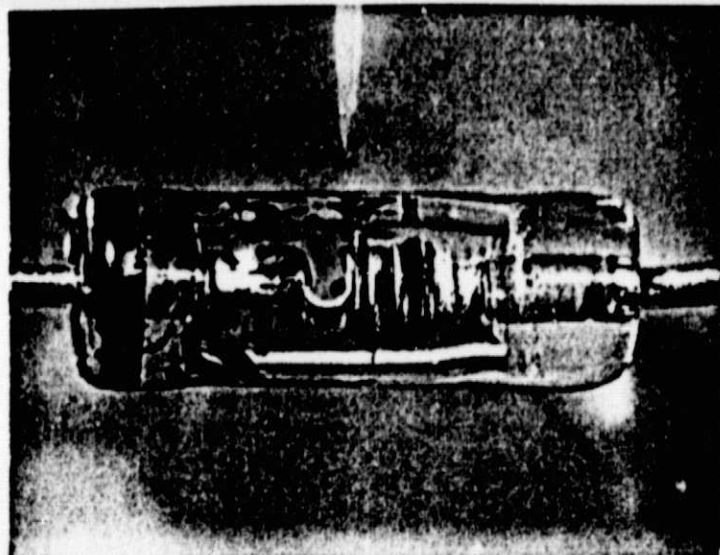


CONCLUSIONS

These Siemens and Motorola diodes are constructed with the two anode dice forward biased and the cathode die reverse biased. When the case was partially ground away so that the internal structures could be probed, all anode (forward biased) dice were operational. The reverse-biased dice of all these samples exhibited soft resistive curves. This indicates damage to the junctions due to micro-plasmas induced by the thermal and electrical stress of the burn-in. (See probe data above.)



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FIGURE A-1
S/N 5188. Typical Siemens Construction, 10X.

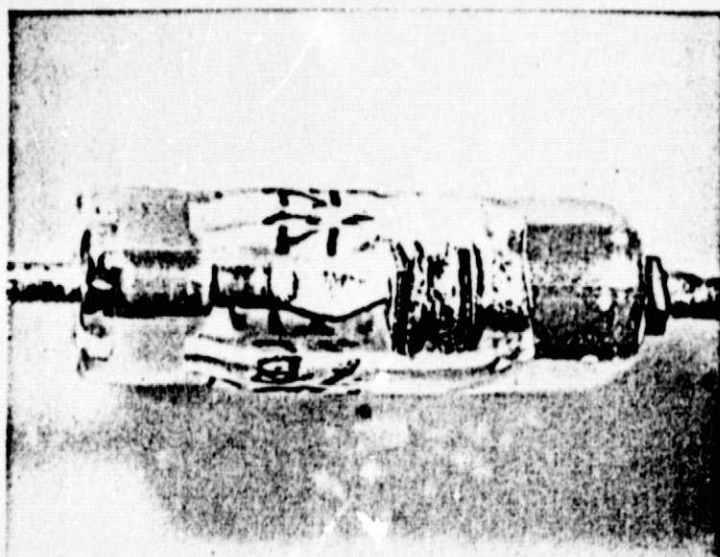


FIGURE A-2
S/N 5236. Typical Three-Dice Motorola Construction, 10X.



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APPENDIX B

FAILURE ANALYSIS

Temperature Stress I



MSFC STEP-STRESS TEST
FAILURE ANALYSIS

DIODES
(160 Hours)

JANTX1N937B

Date 6 December 1978

N 2CN242-36B P/N 1N937B MFR Siemens

End Points:
4.28-14.18V

	PIV -volts- @7.5+.01mA	I_r @ _____ V.dc	V_f @ _____ dc		INITIAL REJ. @ Seq. #:	INITIAL REJ. FOR:
S/N						
90	3.1 (R)				11 (175°C 800 Hrs.)	B_v
95	3.4 (R)				19 (275°C 1440 Hrs.)	B_v
99	4.0 (R)				21 (300°C 1600 Hrs.)	B_v

INTERNAL DIE PROBE

S/N 5195 was opened on one side by grinding and internally probed. Starting from the anode end there were two forward and one reverse biased diodes. The reverse diode junction is damaged. The breakdown voltages of the three dice in normal operation were: shorted, 0.7V, and 2.7V. See Figure B-1.

INTERNAL VISUAL INSPECTION

No significant visual defects were seen.

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* h_{FE} trace present. Cannot meet stated test conditions. (Leaky)

* h_{FE} trace very leaky.

U = drift H = hysteresis Inv = inversion R = resistive S = soft Uns = unstable



MSFC STEP-STRESS TEST
FAILURE ANALYSIS
DIODES
(160 Hours)

JANTX1N937B

Date 6 December 1978

N 2CN242-36B P/N 1N937B MFR Motorola

End Points:
4.28-14.18V

	PIV -volts- @7.5+ .01mA	I_r @ _____ V.dc	V_f @ _____ dc		INITIAL REJ. @ Seq. #:	INITIAL REJ. FOR:
5 46	3.9 (R)				21 (300°C 1600 Hrs.)	B_V
5 49	3.0 (R)				19 (275°C 1440 Hrs.)	B_V
5 55	3.3 (R)				13 (200°C 960 Hrs.)	B_V

INTERNAL DIE PROBE

S/N 5255 was ground opened on one side and internally probed. Starting from the anode end there were two forward and one reverse-biased diodes. The reverse diode junction is damaged. The breakdown voltages of the three dice in normal operation were: 0.7V, 0.7V, 1.9V. See Figure B-2.

INTERNAL VISUAL INSPECTION

No significant visual defects were seen.

*h_{FE} trace present. Cannot meet stated test conditions. (Leaky)

**h_{FE} trace very leaky.

1 = drift H = hysteresis Inv = inversion R = resistive S = soft Uns = unstable



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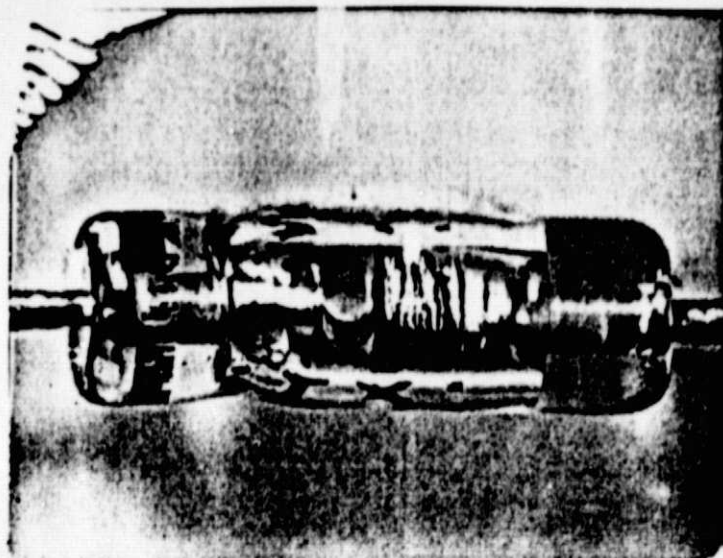


FIGURE B-1
S/N 5195. Typical three-dice
Siemens Construction, 10X.

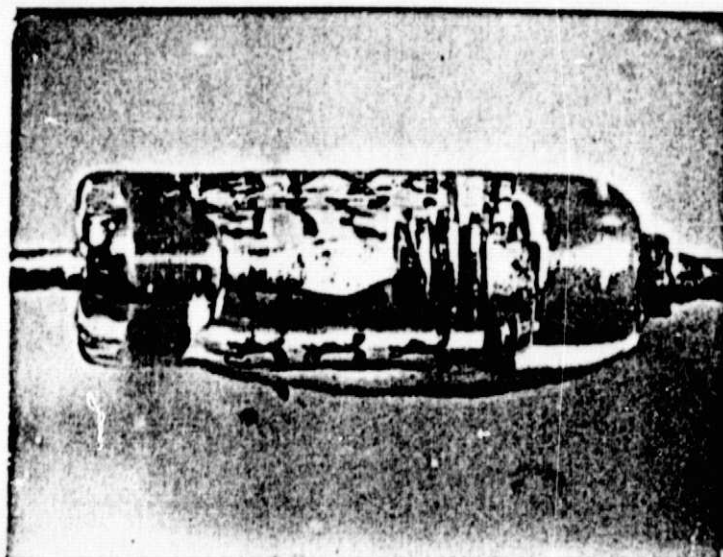


FIGURE B-2
S/N 5255. Typical three-dice
Motorola Construction, 10X.

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CONCLUSIONS

These Siemens and Motorola diodes are constructed with the two anode dice forward biased and the cathode die reversed biased. When the case was partially ground away so that the internal structures could be probed, one anode (forward biased) die was operational. The reverse-biased dice of all these samples exhibited soft resistive curves. This indicates damage to the junctions due to micro-plasmas induced by the thermal and electrical stress of the burn-in. (See probe data above.)